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# PROJECT MANAGEMENT AND THE ORGANIZATION

## PART II

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ABSTRACT

This report examines the organizational structure and relations to the total organization of the Apollo Program hardware research and development projects. It employs a refined model of matrix theory (see Part I, Working Paper No. 20) to relate the workings of the project groups to selected characteristics of their personnel and their tasks. This, in turn, is used to relate the project organization to a general theory of organization. The study particularly focuses on the relations between the project groups and the rest of the NASA organization. The data for the study was gathered in interviews with project managers, subsystems managers, and related personnel at MSC, MSFC and Apollo Program Office and other personnel at NASA Headquarters, Washington, D.C.

Part II discusses the application of the refined model to project groups at MSC and MSFC. Succeeding papers in this series will discuss the implications of the results for the development of matrix theory and organization theory in general.

## SECTION III THE ORGANIZATION OF PROJECT MANAGEMENT GROUPS

This section proposes to examine the project management groups at the Marshall Space Flight Center, Huntsville, (MSFC) and the Manned Spacecraft Center, Houston, (MSC) and compare them to the organizing pattern suggested by Shull's "engineered strategy." This strategy is based on the assumption that relatively specialist/provincial people are doing relatively unique and unprogrammed work. While both of these may be questioned, the combination seems to be an adequate description of the reality.

The first problem that may be raised is whether the personnel are indeed specialist/provincial, especially as distinguished from professional/cosmopolitan. "Profession" is a word that means many things to many people, and "engineering" is a category that covers a broad range of activity. In the aero-space engineering field, the rapid rate of technological advance is such that to be an engineer, in a certain sense, one must do engineering, and to remain a technically competent engineer one must continue to do engineering, or manage strictly engineering work. Thus, the knowledge or expertise is, to some extent, dependent on the firm or the group of firms that constitute the aero-space industry. In this limited sense, at least, the personnel involved are closer to the specialist/provincial position on the personnel characteristics continuum than they are to the professional/cosmopolitan position.

Even the question of unique and unprogrammed work is a matter of degree. Of course, no one, in this country at least, has previously built a giant rocket of the size and power of a Saturn V or spacecraft like the Command and Service Module or the Lunar Module. Still, the same organization, in many cases using the same people, has produced other rockets and other spacecraft. To meet the goal of the Apollo program, the National Aeronautics and Space Administration has utilized existing technology wherever possible. The unique and unprogrammed aspect of the effort lies in two areas, in the development of certain hardware subsystems and techniques, and in the integration of all the various subsystems into a total and unique system capable of doing a very unique task. The first area can be, and often is, contracted out to universities and NASA Research Centers. But the second area is NASA's responsibility and particularly the responsibility of the Apollo Program and its project management groups. Thus, the tasks of these groups can be considered unique and unprogrammed.

## The Marshall Space Flight Center

From 1963 to February 1969, the Marshall Space Flight Center (MSFC) was organized into two operating Directorates and a number of staff offices under the Center Director. The Director for Research and Development Operations (R&DO) supervised the various laboratories which constitute the technical expertise of the Center, while the Director of Industrial Operations (IO) supervised various programs and acted as the Apollo Program Manager for the Center. The Saturn I/IB Program, the Saturn V Program, and the Engines Program all managed research and development

contracts for hardware used in the Apollo Program. The Apollo Applications Program (AAP) also is in Industrial Operations, but manages the development of hardware for a separate program. Most of the Apollo Applications Program personnel had previously worked on the Saturn I/IB and had been transferred to the Apollo Applications Program when the Saturn Programs were combined. These personnel were interviewed for their experience on the Saturn I/IB Program, but their experience with the Apollo Applications Program also provided some insights on particular points.

The Saturn V and the Engines Program were divided into a number of project offices. The Saturn V Program had offices for the S-IC stage, the S-II stage, the S-IVB stage, the Instrument Unit (IU), and the Vehicle Ground Support Equipment (GSE). These are in addition to the staff or functional offices common to the Apollo Program; Program Control, Systems Engineering, Test, and Reliability and Quality Assurance. The Engines Program had offices for the J-2 Engine Project, the H-1 Engine Project and the F-1 Engine Project in addition to the staff offices.

These offices, together with their engineering support personnel from the Research and Development Directorate, constitute the working units for this study. This may appear to be an unusual definition, particularly since it crosses organizational lines and the engineering support personnel cannot easily be identified, by people, including experienced NASA personnel, who are not members of the group. Still, this is one of the advantages of the matrix approach, and membership in the group is usually quite clear to participants. The total membership includes the project manager, the project staff offices (which may vary

from only Program Control to seven various offices or more), the subsystems managers, and the project engineers and other Research and Development Operations personnel working in support of that project.

The proposition generated by the matrix modal for the engineered pattern will be discussed under the heading of the structure, process, roles, style and norms characteristic of the group.

Group Structure

The engineered strategy suggests that the working group would be composed of specialists with a designated project leader. The tendency statement on group structure as formulated in this work also suggests that the group would be relatively homogeneous and the leadership fairly pre-eminent.

The interview data tend to support these suggestions. First, all of the personnel (including the staff office people), are usually engineers. However, the group is not as homogeneous as the model suggests. One project manager with long experience indicates that specialization has evolved. "We tend to be an organization of specialists, while I guess 15 or 20 years ago, we were more an organization of engineers. As our technology advances, it demands that we have these specialists."[1]

It is significant that the basic specialty is still engineering. As another engineer put it, "There's a philosophy at this Center that you aren't a good project manager unless you've been an engineer. I

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[1] Unless otherwise indicated, all further quotations will be from the interview data gathered by members of interdisciplinary research group.

mean, that's felt from the top on down." Thus the project group is composed of and led by engineers. This requires the project manager to work with a number of specialists in his group, and can be a difficult problem. As one former manager put it, "The project manager has got to have enough savvy in engineering to understand what the dickens the experts are talking about and to relate that into the problems of the vehicle." The same man suggested the route most project managers have travelled to acquire that ability. "The project manager usually has to have a degree in one subject and has moved up to various things working on several projects, learns about other guys' problems, other disciplines in engineering."

From a different point of view, a program control chief pointed out, "A good project manager has got to be able to surround himself with experts. He doesn't need, in my opinion, to be an expert engineer and an expert in finance and an expert in contracting and so on, and have degrees in these disciplines. He must have a working knowledge of these things." And the project manager must know how to use these experts. As an engineering manager said, "One professor at school used to tell us, all you guys think you are real hot designers. You people are a dime a dozen. What the world needs is a man who can take all the experts, and tie them together. I think that is what you're looking for in project management."

However, new programs may entail new working relationships, and may present difficult adjustments to people accustomed to the older situation, as indicated in the following statement of an Apollo Applications Program project manager:

> "I think the most difficult aspect relates right back to [the fact] that the scientists do not feel constrained to the formal project organization. They are kind of either aside or cut above or something like that, where if problems come up within the project and we try to resolve them within the project, we find that the scientists do not feel constrained to stay within that environment at all. They'll go to any level that they feel they can go to and get their inputs implemented and this makes it a very sensitive kind of interface. They are part of the project obviously, but on the other hand, they don't feel like they [are] . . . ."

While the evidence on the point is not overwhelming, it does seem that the project groups at MSFC have a group structure similar to that suggested by the engineered pattern. The groups are composed of specialists, are relatively homogenous, and the leadership is fairly preeminent.

Group Process

The engineered pattern suggests that the group process will be somewhat programmed, that coordination will tend to be external rather than dependent on the internalized norms of group members, and that correction mechanisms tend to be external, rather than internalized by group members.

The interviews indicate that correction mechanisms are largely dependent on the project manager. One project manager, in discussing characteristics important to the job, indicated that one of the central ones was "having the experience to recognize symptoms, because as long as a program is going fine, no problems, then you have nothing to do. It is [important] to recognize the smoke signals prior to the fire starting, and get something pointed in the direction of correction." Another project manager said that a good project manager "welcomes problems because a problem to him is a symptom that he's got to get at and

manage, something wrong that he's got to correct. If it's going smooth, he doesn't need to deal with it." The importance of the project manager in the correction process is illustrated by a project manager's comments on the demands on his time. "The higher I get in the organization, the more control I have over my time, I think, as far as it's affected from above [and] the less control I have over my time as far as it's affected from the bottom, because there are a lot of people who are working for me, looking to me for help, assistance, etc., and I must give my time to help them." From the other point of view, the following comments of a subsystems manager bears this out. "I feel that in my particular job I have a responsibility to make sure or to assure him, almost on a daily or half-daily or maybe on a two-hour daily basis, that he is completely aware of all problems on all stages at all sites that might affect his project with respect to the propulsion area." The same man also said, "there's always an attempt to flag out to the project manager essentially the daily status of, say where you stand in your particular area or any problem areas that might come up."

Within the project group, coordination is, to a large degree, the function of the project manager. As one manager said in describing his position, "The thing kind of boils down to that as I see it; assuring that all the many, many pieces that make up the project keep working together, keep working well together and through the kind of guideline that was set up, at least basically within the guideline." The same manager indicated that this activity was indeed a heavy burden on his time. "The project manager gets so occupied with the administrative type problems, the communications, setting up plans and guide lines, all

of this coordination, compromise that needs to be done to get the job done, that he cannot keep up with the technical side of what goes on." Another manager spoke of his position as the focal point of the project. "There has to be a focal point, and that's the project manager. It isn't a question of building up that position, but of giving him all the resources he needs to do a job. It is a natural thing because you need a focal point to make the best and most economical trade-offs." One manager described his position entirely in terms of the coordination of people. "I view the thing as you are the guy who coordinates the efforts of a lot of people, somehow you have to satisfy them by doing less than they would like to see." Another manager described the project manager as a coordinator of resources. "He is mostly a person who can correlate all of those resources and bring them to bear through working with the other line organizations to do this."

The coordination of the project with the rest of the program is an entirely different matter. This coordination is external and relatively mechanical. In fact, one manager ascribed much of this coordination to a specially equipped conference room. "I think probably the greatest thing that helped the Saturn V Program didn't really come very early in the program. This was management control center operation which our Program Control Office set up." This room was equipped with a number of charts depicting the progress of all the various elements of the Saturn V program. These were arranged to give visibility to the critical problems, the various schedule milestones, and similar information. Although it was set up by the Program Control Office of the Saturn V Program, each stage project office was responsible for keeping

its own information up to date, and the date of the most recent posting was indicated. The effect of this visibility was to place great stress on what needed to be done and what areas even threatened to affect the Program's schedule. As that project manager said, "the program control center, . . . the discipline of having that room and that report, etc., has been real good. It probably saved me a lot of time, and a lot of times it forced me to do things that I may have slipped by without doing."

He added that there was a need for different information at different times in the Saturn V program's life cycle. "The center itself has been dynamic and has changed as the program itself has changed, yet the focus has always been on visibility of what's going on right now, what are the tasks and what are the milestones that have to be met to continue the program on schedule."

As important as the program control center may be, it is only one of a number of coordinating devices. Several project managers mentioned the Program Manager's staff as coordinating the various elements of the program. As one program control chief put it, "The Program Manager's staff are the ones that we look to for guidance so that we can do our jobs and make sure that we fit into the total system. We go to them and say, 'This is the particular problem we have today,' and, 'Have you seen it any place else? Maybe we can get some help somewhere.' "

Another project manager viewed the Program Manager's staff somewhat differently. That's what staff are there for and I guess even though we think they cause problems sometimes, they are trying to be sure that we're not doing it differently from everybody else. There are other projects here and when they get ready to issue a policy statement

for guidance, there's a lot of people that should read that over and be sure whether it's consistent with what should be done."

Another Program-level coordinating factor is the documentation procedures used in the Apollo Program. These revolve around the scheduling of various events and the documentation of the actual specifications of the hardware. These procedures were established for that purpose. As a deputy program manager explained, "We have established management techniques to assure that the work of the project managers is coordinated and fits together with the rest of the program. One such technique is the documentation tree requirements."

Several of the project managers referred to a similar device - the configuration management system - which is used to control changes to the design of the hardware. Decisions on changes to the design or configuration are made at various levels, depending on the size of the change in terms of money, time, and the organizational elements affected by the change. The system is designed to give an opportunity to everyone affected to comment on the contemplated change and to insure that everyone affected will be informed of the decision that is made. As one project manager said, "The most significant coordinating thing is the configuration management system we have. I know this is relatively new to Marshall as a Center - it's a few years old."

However, several project managers tended to view these techniques as rather mechanical and inadequate if they were to stand alone. These managers felt that the more important or critical coordination took place through less documentary communication processes, particularly review meetings. As one engineering manager said,

> "The various assessment meetings that we usually have are cross-fertilized between the various stage project offices. At the same time, lab meetings are coordinated through our labs; and this is through meetings, schedule assessments, various technical review, contract review, program manager review, and these lead people who are interfacing, such as the lab man - he becomes a part of the team for information that he can feed back to his system. I guess there is no formal document put out on a regular schedule that establishes this. It is strictly on more of the various schedule assessments; they are published, but not up-dated every month depending on what problems have been."

A former project manager noted the importance and detail of the various reviews. "When you're near a launch, your entire cycle revolves around it, preparing for flight readiness reviews. Right now, at the Cape, we have a tremendous flight readiness review going on to review every stage, every system, all the pieces and make sure all the work has been done before you're ready to fire."

Even the deputy program manager, quoted above on the establishment of coordinating techniques, recognized the coordinating role played by various meetings. "Through the normal course of business, many interfaces develop and many working sessions are required to resolve the compromises. One of the mechanisms for assuring compatibility throughout all hardware systems and subsystems is a working group organization which fits together and assess their own problems."

On the basis of this evidence, one can conclude that the group processes are somewhat programmed; especially in the broader outlines, as suggested by the role of management techniques in coordination with the program. Internal coordination, on the other hand, is largely a function of the project manager, with some internalization on the part of group members of the idea that the project manager should be notified

of a problem as soon as it is recognized. Also, correction mechanisms are heavily dependent on the project manager. Thus, the description of group process outlined in the engineered pattern of the matrix model, fits the MSFC project groups fairly well.

Group Roles

The engineered pattern suggests that there will be relatively little interdependence in the group, but rather, it will be characterized by independent instrumental implementation; and that the leadership role will be relatively well differentiated and center on coordination. The pre-eminence of the project manager and his coordination activities have already been discussed. The statements cited above tend to substantiate this point in regard to the MSFC project management groups.

On independent implementation, one project manager stressed the point quite strongly.

> "I always assume one thing. If I hire a man and I define to him what his job is, it is his responsibility to go. If he has problems, then I am the one he comes to. But, as long as his project is moving, I have no right - once having delegated that responsibility to him - to step in and try to direct him on how he does it. If his method is within the ball park that he's playing in, it should be his and not mine. Because each person has a different personality. And as each level of responsibility a man goes up to, if you try to tell him how to do his job, he will be ineffective. Finally, he will become so ineffective that you do all of his work for him. So, give a man his job, instill in him that it is his responsibility, and let him go."

Another project manager stated that he preferred to work in that sort of a situation. "I like to have a job and have a good bit of leeway on just how I get it accomplished. I think the program manager does an excellent job there. We give him adequate visibility, so that if we're goofing up it wouldn't take him long to determine the cause - he has the

necessary visibility."

A third project manager felt that an ability to handle people in a fairly independent situation was critical to a project manager. "He has to be willing to delegate responsibility and authority on the job, have the pieces defined and the overall package worked out so that everything fits together, and have a good system of visibility."

Another manager suggested that this sort of independence was a characteristic of engineers. "Engineers are usually very good in working out a little, little, little subsystem, or a system. So, they can work that corner there very well. Another guy works that one, and there are many little pieces."

The same man indicated that all engineers do not fit the pattern. "You can put them in two categories. Roughly, the 'self-starters,' - the guys you can sit down with and talk to, as we are right now, and just discuss it. No more than that. They will grab the ball, run with it, and you don't have to worry. Then, there is the other category. You can sit with them for days, lay out in detail what they are to do, and they still can't do it. They will always come running back to you and want more guidance; or even they, in fact, want you to solve the problem for them."

On the whole, the usual and the expected role is one of independent implementation on the part of the engineers and coordination on the part of the project manager. Thus, the roles specified by the engineered pattern, are descriptive of the MSFC project management groups.

Group Style

The engineered pattern suggests that the group style would be

marked by high stress. The interviews did not yield sufficient data to test the proposition, but it can be observed that high stress does seem to be a mark of the entire Apollo Program.

There were many remarks about personnel working overtime without pay in order to resolve problems and meet deadlines. But this atmosphere, or style, would seem to be as much a factor of the Apollo Program as of the organizational arrangements. It seems exceedingly different to separate these in order to analyze the origins of this characteristic in this instance and the proposition cannot be tested adequately in the current study.

Group Norms

The matrix model suggests that a group organized along the lines of the engineered strategy would have norms of both individual responsibility and shared responsibility, group loyalty and economy, and efficiency. The interviews did not yield sufficient data to test this proposition. There was one comment which, interestingly, lends support to individual responsibility as a norm of the MSFC project manager groups. A former project manager who had moved into a program staff office explained, "I haven't heard Dr. Von Braun [the Director of MSFC] express himself very clearly on it, but he has what he calls 'automatic responsibility.' He says that you are responsible for whatever falls into your area - automatically. I don't have to assign anybody else to it, and if it doesn't work, it's your fault."

The Engineered Pattern and the Organization of MSFC Project Management Groups

On three out of the five organizing characteristics that the model

specifies, the interview data indicate that the hardware project management groups at MSFC are organized along the lines suggested by the dominant nodal pattern appropriate to their particular combination of personnel characteristics and task characteristics. On group structure, group process, and group roles, the data support the propositions of the matrix model. On the other two characteristics, group style and group norms, there is not sufficient evidence to test the propositions, but there is some support and no conflicting evidence. The practice of project management at the Marshall Space Flight Center seems to follow the organizing strategy indicated by the engineered pattern of the matrix model.

## The Manned Spacecraft Center

The Manned Spacecraft Center (MSC), Houston, Texas, is organized quite differently from the pattern of the Marshall Space Flight Center. Under the Director of the Center, there are some five operating Directorates. These are: the Director for Engineering and Development; the Director of Science and Applications; the Director of Medical Research and Operations; the Director of Flight Crew Operations; and the Director of Flight Operations. The various program offices are not centralized under one office, as at MSFC, but report directly to the Center Director. These are the Apollo Spacecraft Program Office; the Apollo Applications Program Office; and the Advanced Missions Program Office. The title of "Apollo Spacecraft Program Office" may have been chosen to emphasize the fact that all of the operating Directorates have responsibility for some aspect of the Apollo Program. Of course, the same will be true of future manned space flight programs.

The Apollo Spacecraft Program Office (ASPO) is also organized quite differently from the program offices at MSFC. This office is headed by a Manager, and within the Manager's Office are a Manager for the Lunar Module (LM) and a Manager for the Command and Service Module (CSM), the two vehicle systems for which the Apollo Spacecraft Program Office has the responsibility. These managers do not have any personnel reporting to them in an administrative sense and are not considered separate organizational elements. Under the Manager of the Apollo Spacecraft Program Office are the Program Control Division, the Command and Service Module Project Engineering Division, the Lunar Module Project Engineering Division, the Systems Engineering Division, and the Test Division. The fifth of the Apollo functional offices, Reliability and Quality Assurance, has been elevated to a Center staff function, as was mentioned earlier. The Program Control Division has a Lunar Module Contract Engineering Branch and a Command and Service Module Contract Engineering Branch, while the Systems Engineering Division has a Lunar Module Engineering Office and a Command and Service Module Engineering Office. All of these engineering offices would seem to overlap, but there are some fairly unambiguous distinctions. The Contract Engineering Offices provide technical support to the contract negotiations, as well as exercise the program control function for their vehicle system, either the Lunar Module or the Command and Service Module. The Project Engineering Divisions provide vehicle managers who follow a particular vehicle, from initial manufacturing to final disposition, and assure that any problems along the way get prompt attention. The Systems Engineering Offices are concerned with major problems that require changes

to all the vehicles of a particular series, either Command and Service Module or Lunar Module. As was mentioned earlier, the subsystems managers are located in the Engineering and Development Directorate for the most part, although they report to the Apollo Spacecraft Program Office for program direction.

Due to these arrangements, the definition of the relevant working groups at MSC is somewhat more problematical than is the case with MSFC. For this study, the project management groups are defined to include the Manager for the Lunar Module or the Manager for the Command and Service Module, the Contract Engineering Office, the Project Engineering Division, the appropriate Engineering Office of the Systems Engineering Division, and the appropriate subsystems managers and support personnel in the Engineering and Development Directorate. Even more than is the case with MSFC, these are groups that are bound together by what they are doing rather than organizational definitions.

Again, the various propositions will be discussed under several headings. These include group structure, group process and group roles. The interview data did not test the propositions on group style and group norms at MSC.

Group Structure

The matrix model suggests that the working group in the engineered pattern would be composed of specialists with a designated project leader, relatively homogenous, and the leadership fairly pre-eminent. While the interviews at MSC did not fully probe these points, some indications can be derived from the responses. One significant point is that of the

sixteen NASA personnel interviewed at MSC, one had a completely non-technical educational background, while three others had technical but non-engineering educational backgrounds. Of course, all these people were doing some sort of engineering, and for many kinds of engineering, a degree in the physical sciences is as good as any other. Still, this gives the preliminary indication that project management groups at MSC are somewhat less homogenous than those at MSFC.

The interviews indicate that the project manager has a central leadership position. One project manager said, "I don't let anything go out to the contractor, directions or information, without me seeing it first. So I read outgoing mail and I read incoming mail [after it is] screened for the things I want to see."

Another member of the group said of the project manager, "He is intimately involved with everything I do. Of course, he's the focal point for the program."

One of the suboystems managers highlighted the importance and difficulty of communicating with the project manager. "The toughest kinds of problems are getting across to the project manager your concept, your proposal to accomplish the job. I mean, in terms of he understanding really what you want to do and how will it be implemented. He usually wants to know much more detail than what you think he should."

However, the Apollo Spacecraft Program Manager is also providing a good deal of leadership, as one project manager pointed out.

> "The Apollo Spacecraft Program Manager has meetings every morning, at 8 to 8:30, or 8-9, reviewing the status of each of our upcoming vehicles, mission plans and he knows every day what our problems are and what we have done to rectify or alleviate these problems. We have a Change Board, once a

> week, every Friday, which he chairs. We have a Change Panel every Monday, which he does not participate in, but the minutes are out and he approves them so he knows what went on. He has a pretty good finger on the pulse of the program in real-time."

This situation is illustrated by the comments of one engineer.

> "My immediate supervisor is the Manager for CSM and, of course, his door is always open to me. I probably talk to him maybe five or six times a day. Then the ASPO Manager's door is also open to me. However, I do have formal briefings with the ASPO Manager, set up on Tuesdays and Thursdays from 8 to 9. For example, when Apollo 9 is on the pad, I may have a problem right now, I may get a call from the project engineer at KSC [Kennedy Space Center] who'll say I have a problem right now. I'll get as much facts as I can on the problem, I'll come up with my recommended solution and then I'll call either the Manager for CSM or the ASPO Manager, and say, 'I've got a problem, I've got the story. I'd like to go over it with you and get a decision from you right now.' "

On balance, it can be said that the suggestions on group structure seem to apply to project management groups at MSC, with the exceptions that the group is somewhat more diverse than might be indicated and the project leadership is shared with the Apollo Spacecraft Program Manager.

Group Process

The engineered pattern suggests that the group process will be somewhat programmed, that coordination will tend to be external, rather than dependent on the internalized norms of group members, and that correction mechanisms tend to be external, rather than internalized by group members.

The interviews yield relatively little support for the view that the work is relatively programmed. One manager of a project outside of the Apollo Spacecraft Program Office (there are several in this category which develop hardware for the Apollo Program and receive program direc-

tion from the Apollo Spacecraft Program Office) noted a difficulty in getting test requirements established. "The major problems were in getting the requirements established. The test people don't like to think about it, perhaps because automation seems to take away jobs. And, they didn't really know what the requirements were. As a result, they had to design the equipment to a range of requirements, but getting even these established was a problem."

This would seem to indicate that the work was relatively unprogrammed or that there was a difficulty in programming it. The comments of an engineering manager point out that some factors are usually known. "I usually know what constraints I have with the vehicle for getting a problem resolved and so they usually allow me to [set my own schedule]."

One of the vehicle managers also indicated that the limits on the day to day activity were well enough known. "We are allowed a considerable amount of freedom to operate within the bounds of our spacecraft. So, it becomes a liaison type of thing. We receive direction from him, we feed information to him, and we ask for directions, but it's, more or less on an exception basis."

On balance, it would seem that the decision process was a mixture of programmed and unprogrammed, with a bit more emphasis on the unprogrammed than was the case with MSFC.

There was some indication of external coordination, through meetings and project leadership. One engineering manager suggested, "Coordination is also enhanced, to a large extent, by the review-type meetings that we have, the acceptance reviews of spacecraft, pre-flight readiness reviews, tend to get all the different elements together and talk about the same problem. I think it helped a lot in the coordination."

The same man stated that he consciously uses meetings as a coordinating tool. "As a coordinating device to pull the information together, I hold twice a week meetings with the Apollo Spacecraft Program Manager reporting up what we are doing and looking at what other people are doing. These are the morning stand-up kind of meetings that operate quite efficiently. I hold weekly staff meetings with my own people."

In particular, the Configuration Control Board (CCB) seems to be a strong coordinating factor at MSC. The Configuration Control System is composed of a number of levels. At the lower levels there is a Change Panel for the Command and Service Module, which is chaired by the Manager for CSM, and a Change Panel for the Lunar Module chaired by the Manager for LM. Changes approved by these panels must be within a cost ceiling set by the Apollo Spacecraft Program Manager and must be confined entirely to the particular module. Any change proposed for the Command and Service Module or the Lunar Module which would require a change in the other module, or in any other piece of the Apollo/Saturn system, must be submitted to higher levels. In cases in which the proposed change exceeds the cost ceiling or in which the members of relevant Change Panel cannot reach agreement, the proposal goes to the Apollo Spacecraft Program Configuration Control Board for decision. This Board is chaired by the Apollo Spacecraft Program Manager and includes the heads of the various MSC Directorates.

One of the subsystems managers pointed out the role of the Configuration Control Board in making decisions. "If someone is asking for a change or if we think a change is required, and the medics won't

buy it, crew won't buy it, or anyone else around won't buy it, we ultimately end up with the head of ASPO. He gets everybody around the table. He has his Configuration Control Board meeting him on Friday. Everybody brings their changes and problems, whatever have you, to the meeting."

One of the vehicle managers put it somewhat more bluntly when he said, "That CCB is where the program is made."

Several people tended to view the coordination process somewhat differently. For instance, one of the project managers denied that any one technique was the coordinating factor and said, "I think we're particularly fortunate here at the Center to have some extremely competent people, and it's just the interplay among those people that tends to focus attention on the things that aren't getting done. And I think with our things like our Configuration Control Board which keeps all the directors involved across the whole Center, the normal day to day activity keeps them so much involved in it that it's very difficult for a problem to fall in a crack."

One of the engineering managers felt that communication and coordination was his most difficult problem, and his example seems to point to the necessity of internalized coordination.

> "Probably the toughest problem we have is communication and coordination. And examples can be made of that when we make a decision. When I make a decision to do something, I want to be sure that the subsystems manager understands what I'm doing. I want to be sure that the Flight Operations people understand what we are doing. I want to be sure that the Flight Crew Operations people understand what we're doing. I also have to be sure that the contractor agrees and understands what I'm doing. If it's an interface that affects another contractor, I have to be sure that the people who work with them here understand what I'm doing. It may affect

> Marshall or KSC. So, normally, what I do is, in making the decision, I get on the phone and just start talking on the phone. I coordinate it and I document it in a memo and whoever I think it may - I mean there's no written rule who I talk to - I guess I just have to use my judgment, and then I document it either from myself to my boss or to the ASPO Manager, or from my boss and ASPO to the Center, or KSC, or whoever it could be."

Another engineering manager's description of his most vexing problem seems to point in the same direction.

> "I think the most vexing thing has been the lack of definition of responsibilities. For someone to have layed out all the things that need to be done and to say, alright, we need to have a subsystems manager for this widget, and to make sure that everything is covered and some guy is responsible and knows exactly what he is responsible for. We have these understandings in a general kind of way, but neither are the scopes or the levels of responsibility. Nobody is really sure what they're responsible for."

It would seem then that coordination within the project management groups at MSC depends, to some extent, upon the group members, though the project managers do play some role in this, and the Program Manager, through the Configuration Control Board, is the final coordinator.

The interviews seem to indicate that correction is, to a degree, external, rather than internal. As one project manager said, "Quite often, what we come out of these meetings with, say the project engineer or subsystem manager, or some specialist has been working on something and he is not getting the results he needs. So the ASPO Manager or myself or the other project manager may want to call our counterpart at the contractor's plant and say how about getting on this, devoting some of your attention to it."

However, this does not mean that there is a standard procedure for handling problems, as the comments of one of the engineering managers indicates. "When it's identified, we usually assign someone to the

problem, but it's not dealt with in a very rigorous kind of a way, like saying we must be sure we have a consistent rule for handling this kind of problem in all subsystems."

And the correction mechanisms are to some extent dependent on the project group members' initiative. One of the vehicle managers indicated that correction processes are initiated at times by recognizing a problem. "I'll let them know the problem, let them know what I'm doing from time to time, when I'll have a resolution for them, and if I need help in getting it resolved, like, if I need help, top-level help from Washington or top-level help from Marshall or KSC. If I feel that it's really something I really can't handle, I'll let them know that also."

But the basic process of correction seems to be best described by the following statement of a manager for one of the projects outside of ASPO.

> "We are trying to get a change made for LM-5 right now, we have a big change we want to make, it's been proven. My project engineer on that particular item prepares the story, gets the understanding, and if he agrees with it he gives it to me; and, of course, we go back and forth, and we get an understanding and we change a few things when I think, from my experience, it might work a better way. I ask questions which he might not have answers for, and try to think what might be asked of me when we go to the next level. . . ."

The group process specified by the engineered pattern would seem to generally apply to the MSC project management groups, with the exception that the decision processes are somewhat more unprogrammed than would be indicated. Coordination depends, to a large degree, on external factors, especially the project manager and meetings, and correction is more external than internal.

Group Roles

The engineered pattern suggests that there will be relatively little interdependence in the group, but rather independent instrumental implementation, and that the leadership role will be relatively well differentiated and center on coordination. Again, the importance of the project manager and his coordination role have been discussed above under group process, and the only additional point to be made here is that the Apollo Spacecraft Program Manager also shares some of the coordination and leadership.

The MSC project groups do seem to be characterized by independent implementation. One project manager emphasized individual responsibility. "When there's some action that must be taken we like to assign some individual that is responsible for that action. If you don't make somebody responsible, if everybody is responsible, you never get an answer." The same manager described his operating philosophy in similar terms when he said, "No matter what the organization is, you pick out a few people that you have the most confidence in and you pretty well let them make the routine decisions, and make sure that their work is progressing while at the same time they're keeping you appraised of the problems, potential problems, and their schedule for resolving the problems."

From the other point of view, one of the vehicle managers described the process of sharing information about problems, indicating the independent implementation. "We just have round table discussions about the problems that are applicable to our given spacecraft, and so they get laid out on the table and from that the other guys pick up flags to problems they might have and that kind of thing."

These representative comments indicate that the propositions on group roles suggested by the engineered pattern substantially apply to the project groups at MSC.

The Engineered Pattern and The Organization of MSC Project Management Groups

Again, on three out of the five organizing characteristics which the model specifies, the hardware project management groups at MSC are organized along the lines suggested by the appropriate nodal pattern. On group structure, group process and group roles, the data support the propositions derived from the model, while on group style and group norms, the data do not test the propositions.

There are some significant differences in the application of the model to MSC as compared to MSFC. On group structure, the MSC groups seem less homogenous and the group leadership is shared with the Program Manager. On group processes, the decision processes at MSC are somewhat more unprogrammed than is the case at MSFC, and more so than the model would indicate for the engineered pattern. These differences will be examined further in a later section.

Summary

This section describes an attempt to apply the propositions on group organization derived from the matrix model to the Apollo project management groups at MSFC and MSC. The interview data tested only the propositions on group structure, group process and group roles in each case. The propositions were generally substantiated by the interview data, but seem to apply more neatly to the MSFC project management groups than to those at MSC.

## SECTION IV. PROJECT MANAGEMENT GROUPS AND THE ADMINISTRATIVE SYSTEM

This section describes the relationship between the Apollo project management groups and the administrative system in terms of Shull's matrix model. It must be remembered that this approach takes a systemic view of the organization. The system concept as used here is distinctly an analytic concept. As such it is imposed on the phenomena in an attempt to understand or explain it. Perhaps one of the more difficult aspects of systems theory is the definition of boundaries. While there are no theoretical problems of boundary definition, in practical application the boundaries are difficult to define in a way which is both useful to the analyst and meaningful to the participants.

While the definition of the bounds of the project management groups used in this study (see Section III) may be unusual, they seem to be useful for present purposes and perhaps meaningful to the participants. A similarly useful and acceptable definition of the bounds of the administrative system is more difficult to delineate. Shull places all non-operating task groups in the administrative system,[1] but this is merely a catch-all definition which does not serve to identify the groups to which the propositions derived from the model are to apply.

The particular problem with the Apollo project management groups is that there seems to be an overabundance of administrative systems. The

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[1] Shull, op.cit., p. 16.

Program Manager and staff, at least at MSFC, could be considered the first-level administrative system. The Center Director and staff at each Center could be a second-level administrative system. The Apollo Program Office at NASA's Washington Headquarters could be a third-level administrative system. And the Administrator and staff of NASA could be a fifth-level administrative system. In such a case, the various levels would constitute subsystems of the next higher system. As such, inputs from each system would affect the behavior of its subsystems, from the highest to the lowest level as well as from the lowest to the highest. The higher level systems would tend to define the parameters within which the lower systems operate. This could be visible to the participants at the project group level, or they might consider only the actions of the immediate administrative system. For various reasons, the multiplicity of administrative inputs is quite apparent to the Apollo project management groups. Thus it would be difficult to speak of a single administrative system in meaningful terms.

As a practical resolution of the problem for the present work, the administrative system will be defined as those entities within NASA which place constraints and requirements upon the project management groups and legitimate these constraints and requirements on the basis of organizational authority. The main thrust of this definition is to exclude the functional support groups, which legitimate their constraints and requirements on the basis of technical expertise. In concrete terms, the definition identifies particularly the Program Manager and staff, the Center Director and staff and the Apollo Program Office as the main components of the administrative system. Of course, the Office of Manned Space Flight and the Administrator of NASA and staff arms of these entities play

a role in generating administrative requirements. Indeed, many requirements are generated, or at least ratified, entirely outside of the organization. Congress must approve money authorizations and appropriations and the Civil Service Commission establishes personnel guidelines - both of which have some effect on project management groups.

The inclusion of the Field Center Program Managers in the administrative system may present some problems. These are highly technically oriented managers, and are very much task oriented. Indeed, as mentioned in Section III, at MSC the Apollo Spacecraft Program Manager takes a real share in the project leadership. Still, these are, as far as the project management groups are concerned, managerial rather than operating groups. Their main concern is not to accomplish the task, but to see that it is accomplished by other people in conformance with program requirements. In a certain sense, the Apollo Spacecraft Program Manager may play both of these roles, and at times it may be difficult to tell which role he is playing. Such difficulties will not constitute a major problem in the analysis.

## The Marshall Space Flight Center

The relationships between the MSFC project management groups and the administrative system will be discussed under the headings of planning, control, and boundary negotiations. The propositions on reward relationships were not tested by the MSFC data.

### Planning

The model suggests that for a group in the engineered pattern, the ends will be specified by the administrative system, the resources will be specified by joint negotiation between the administrative system and

the working unit, while the process will be determined by the working unit.

The specification of ends and process seem to be quite well covered by the comments of a Research and Development Operations project engineer. In an interview with other members of the research group, he said, "the original requirement comes from management. It's up to the R&DO [Research and Development Operations] side to lay this all out in an engineering fashion in the proposal state. And Industrial Operations really doesn't get into this thing too much in the initial phase . . . ."

From the project manager's point of view, one project manager traced his job back to the planning stages in terms which substantiate the propositions of the model on both process and resources.

> "I think it includes everything related to that, it includes everything from estimating and going in and asking for the money, or requesting the money, or fighting for the money. It includes getting the money for the project. It includes writing the statement of work, deciding who's going to build it, which contractor will build it, and sitting in and arranging for the negotiation for that contract and then it includes deciding on the changes from that time on . . . ."

The Apollo Program was well advanced when these interviews were conducted and had been in existence some seven years. In addition to personnel shifts and hazy memories, the discussion of the planning responsibilities was impeded by the fact that the organization had been realigned since the inception of the Program. One Apollo Applications Program project manager who had been in the Saturn I Program described the impact of the organizational changes.

> "At the outset of the Saturn I Program, they referred to it as the Saturn systems office and that office controlled the requesting of dollars from headquarters. I find that that is approximately about what they did. Yes, they got into technical discussions, but the final decision was with Research and Development. From that

evolved the creation of Industrial Operations. This was when the project managers started to come of age . . . ."

The Apollo Applications Program is much more recent than the Apollo Program and as such, is closer to the planning stages. Thus, the project managers in the Apollo Applications Program are more aware of the planning responsibilities. One of these emphasized planning as important to the project managers. "I think a project manager should first and foremost have the ability to plan effectively and communicate effectively, organize effectively and compromise and that kind of thing."

The same manager indicated that he had been with his project since its inception, and even prior to that time. "I got involved in this present assignment when Marshall was making its initial proposal to NASA headquarters to take on the project which was in March, 1966, and of course, we didn't get approval for the project until I guess it was August, 1966, but essentially I had the responsibility I have right now for three years."

This has not been the case with all of the Apollo Applications Program project managers, as one manager pointed out. "The Program is over two years old and I've been here since January. There's a lot of decisions and reasons for decisions that were made that I haven't learned yet."

On the division of planning responsibilities, the balance between the administrative system and the working units suggested by the model for the engineered pattern would seem to apply to the situation at the Marshall Space Flight Center. The ends seem to have been basically specified by the administrative system, the process determined by the working units and the specialists involved, while the resources were

determined by the requesting-approval process which can be reduced to joint negotiation.

Control

The model suggests that for a working group in the engineered pattern the controls specified by the administrative system will be fairly specific. These will include the specification of critical control points, and the specification of input and output controls in terms of financial parameters defined by the administrative system. Process controls would be lodged in the working unit and feedback on input, output and process would be transmitted to both the working unit and the administrative system.

The question of control points was not probed in the interviews since adequate information on the Apollo Program scheduling and reviewing process is available in published documents.[1] These give sufficient evidence to conclude that critical control points are indeed used in controlling the work of the Apollo project management groups.

One project manager described the process of determining the financial parameters in terms which aptly sum up the responses of most of the other personnel interviewed.

> "The decision on the total amount we get is made at headquarters. But that's made after we send the requested budget in there, and that's adjusted several times, and we get an indication that we'll get somewhat less than that or somewhat more than that. They usually want more detail on why we need it and it's negotiation back and forth. So the allocation of money comes from there, but the decisions on what to spend it on are made here."

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[1] See especially National Aeronautics and Space Administration, Office of Manned Space Flight, Apollo Program Office, NASA-Apollo Program Management, Vols. 1 through 4, (various dates).

There is some question about the role of the financial parameters as a control on the project management groups. One project manager said in regard to resources, "We've kind of been the king-pin program in NASA ever since I've been with this project office. Obviously we never had much of a problem there." And a deputy program manager only pointed out the obvious when he said, "we've enjoyed a relatively high priority for the Manned Lunar Landing Program. Along with the priorities come the resources."

But one project manager who moved into a staff position indicated that the determination of financial parameters does present some problems to the project management groups.

> "I think the biggest difficulty we have within the NASA setup is that NASA is bound by the periodic budget exercises. In other words they can't plan very definitely for a long range. You never know year to year how much you're going to have in the way of resources to do something. So we go through changes in the direction that you're going, generally in the same direction, but you must take a lot of sad tangents because of fluctuations in the available resources and I think in the long run, this costs the government more money."

Thus even in a generally well funded program, the establishment of financial parameters act as controls.

The Apollo Program is in a unique status as far as financial resources are concerned as is evidenced by the statement of one project manager who speaks for the entire Apollo Applications Program. "Right now we have a particular dilemma in that we have limited resources and the job we want to do is not consistent with the resources available. And that truly is the biggest problem right now. It's how can I accomplish the predominance of the requirements with the funds available."

On balance, it can be said that there is at least an attempt to define financial parameters as an input and output control, but that the utility is diminished by the priority which the Apollo Program commands.

One project manager commented on the role of the program manager's staff. "The person I report to has several people who, in the staff office, are reporting to him. They're in a position of establishing policies which we have to carry out. A lot of times it involves doing jobs differently from what we want to do or at more cost than we think we can spend for it or take maybe a lack of understanding of what we think is required." This was the only indication in the interviews that the administrative system might be taking a hand in the determination of process controls. On the whole, it would seem most likely that the majority of such determinations were made by the engineering specialists in Research and Development Operations in cooperation with the Project Managers in Industrial Operations.

The reviewing system of the Apollo Program, which is described in the Apollo Program Management manuals referred to above, constitutes a powerful feedback mechanism. As one project manager described it, in the Apollo Program "you have a piece of NASA which communicates almost within itself in a circular loop."

Indeed, some managers felt that the reporting requirements were too great. One former project manager described a tendency to overreport. "We report, for example, things that shouldn't be reported. They're not problems, but to someone that didn't understand about it and heard it, it's a problem. We can't afford not to bring it up and say look, this is what we're doing."

The same manager described the reviews as the major outside demand on his time. "I follow my own inclinations with the exception of external requirements for reviews, status reports and so forth and they were rather demanding. Early in the project we found that each layer of management, from the top to the bottom, had its own idea of a reporting series and the project manager handled them all."

He added that heavy communication was required for the success of the program. "In fact, I think it couldn't successfully proceed [without that communication] because the Program Manager had to be that aware of the number of problems and status so he could make his tradeoffs and report adequately to the next higher level." Thus, it would seem that the project management groups are indeed part of a communication network which provides feedback to both the administrative system and to the project groups.

In total, the propositions on the control relationships apply fairly well to the MSFC project management groups. Control points are specified, financial parameters are defined, though this control is weakened by the funding support available to the Apollo Program, process is generally left to the project management groups, though there may be some influence here on the part of the Program Manager, and feedback is directed to both the administrative system and the project management groups.

One possible control that the model does not discuss is personnel. The Apollo Program and NASA, as a government agency, are under the general Civil Service rules and procedures, for the most part. In addition, they come under general attempts, by the President or Congress, to limit the number of government employees. For these reasons, or perhaps because

MSFC was, at the time of the interviews, attempting to implement a Reduction in Force, personnel restrictions were fairly prominent in the minds of many of the MSFC project management people. One project manager indicated that they constituted his biggest problem. "My basic problem as far as any organization is concerned is that no one in government seems to have any control over being able to apply the needed skills where they're needed."

One of the deputy program managers compared the situation to that found in industry. "The project manager in industry has a lot more freedom, especially with personnel. We seem to think that we don't have as much freedom in the personnel areas, like the hiring and firing to be quite blunt - promoting and demoting."

A former project manager who had moved into a staff position thought that the projects were competing for the available manpower. "I think the only competitive process I see is from the lack of civil service manpower the stage manager has working for him. See, we're in a manpower phase-down situation. Everybody's trying to hold on to all the manpower he's got."

On the other hand, another project manager recognized the problem, but felt that it was not serious. "We would like to have a few more people in here, a little bit larger group than we've had at times, but I wouldn't say we've had any serious problems."

It would seem that the personnel restrictions are not so much a control used by the administrative system as a peculiar circumstance of the organization. Of course, from the larger point of view, these are controls enforced in an attempt to implement overall governmental policy.

Boundary Negotiations

The model suggests that for a working group in the engineered pattern, resources would tend to be a legitimate subject for negotiation, and that the administrative system would tend to emphasize resource parameters while the working group would tend to emphasize output-feasibility and that once the program is crystallized, renegotiations would tend to be legitimized by the working unit on the basis of process requirements. The interviews do not test these propositions adequately but some comments would seem to indicate that they do apply to the MSFC project management groups. The comments of one project manager indicate the adjustment of process to the financial parameters. "The amount of resources you need and the amount of resources you would like to have are not always the same, either. If you had more money you might do things differently. You might work more exotic resolutions to your problems." And the comments of a deputy program manager, here considered as part of the administrative system, illustrate the adjustment of budgets of financial parameters to achieve the desired output. "We may have to eliminate some of the questionable areas of expenditure so that the problem can be solved. We have to divert funds to cover this. It is an iterative situation between us and labs."

In addition, the comments included in the sections on planning and control amply illustrate the negotiation processes by which the financial parameters are established. The comments of a former project manager now in a staff position also substantiate the suggestion that these are subject to negotiation.

> "In the majority of the cases, we go in with what we want and it's kind of an unwritten agreement with headquarters that they will cut the Center budget and not in the individual accounts, though in the past POP they did single out accounts that they wanted to have certain money removed from. When the money comes back, generally speaking unless headquarters has isolated a specific account, the Center by precedent will take a pro rata share of the cut and apply that to all the accounts. So they really don't get into the judgment."

In total, the support for the model's suggestions on boundary negotiations is rather strong though the interview data do not provide a full test of the propositions.

The Administrative Relationships and the MSFC Project Management Groups

Of the four characteristics of the relationships between the administrative system and the MSFC project management groups specified by the model, the interview data substantiate two, strongly support a third and do not test the fourth. The planning responsibilities appear to have been divided along the lines suggested by the engineered pattern. The control relationships suggested by that pattern seem to apply to the MSFC project management groups, though the definition of financial parameters as a control is somewhat weakened by the generally high funding levels of the Apollo Program. The propositions on the reward relationships are not tested, and the propositions on boundary negotiations are rather strongly supported by comments made in the course of the interviews.

The Manned Spacecraft Center

The relationships between the MSC project management groups and the administrative system will be discussed under the headings of control, rewards and boundary negotiations. The propositions on planning were not tested by the MSC data.

Control

The model suggests that for a working group in the engineered pattern the controls specified by the administrative system will be fairly specific. These would include critical control points and input and output controls in terms of financial parameters defined by the administrative system. Process controls would be lodged in the working unit, and feedback on input, output and process would be transmitted to both the working unit and the administrative system.

The comments on the Apollo program schedule and review processes in the discussion of the control of the MSFC project management groups apply here also. An additional support for the proposition that critical control points are used in the Apollo Program is one engineer's comment that his division "has a review planning organization for the various Headquarter's type milestones that we must support, like flight readiness reviews and customer acceptance readiness reviews."

The specification of inputs and outputs in terms of financial parameters seems to be achieved similarly to the method used at MSFC and appears to suffer the same deficiencies. One project manager commented that the Apollo Program had first priority on funds. "Particularly for the last several years Apollo has been a national goal. The agency has used its money to do Apollo and only if there's anything left over does it get spent on other work." On the other side of the question, one of the subsystem managers on a project outside of the Apollo Spacecraft Program Office felt he was somewhat more constrained on financial resources.

> "I don't think anyone really feels that they have all they want or all they need. I'm very limited on what I can do here. For

> instance, I can't spend money unless it's already inside the contract. If there's a new requirement, it has to go to higher authority than me to be justified. I make recommendations and in most cases the recommendation holds, but that's not necessarily true."

On the feedback mechanisms, one of the Contract Engineering managers described the situation in terms strikingly similar to one of the comments reported from MSFC. "I think we've closed the loop pretty good, as far as keeping all members of the NASA management informed."

He added. "We, of course, submit reports out through ASPO to headquarters on our costs and schedule situation. We track the change budgets very closely."

One of the project managers mentioned one part of the feedback process. "We submit to headquarters each month a set of charts which shows what our status is and how we are progressing against the program plan."

Another project manager described the process in somewhat more detail, including the Apollo Spacecraft Program Manager's position in the feedback loop.

> "The Configuration Control Board is kind of a method of keeping track of things and that involves the ASPO Manager. In addition there are a series of reviews and meetings which require information and presentations from me. Such things as the Monthly Program Reviews at the contractor's site, the Monthly Management Council at OMSF, [Office of Manned Space Flight] the Design Certification Reviews, the Flight Readiness Reviews right on down to the Post-Mission Reviews. These all require him to follow things pretty closely."

Finally, the comments of one of the Contract Engineering managers on changes illustrate the contention that feedback applies to input, output and process.

> "There has been very close coordination between headquarters and ASPO, from my office and the corresponding office at headquarters on what contract changes have we authorized, what is in work,

> what's out for proposals. In fact we report weekly, jointly, to headquarters and they appraise the Apollo Program Director and OMSF [Office of Manned Space Flight] monthly on all the changes in the program. Not only what the change was, but effectiveness, cost, etc. They also monitor our change budgets."

The MSC project management groups appear to be under the same types of controls as those at MSFC. Control points are specified, financial parameters are defined, though this control is weakened by the high funding levels, and feedback is directed to the administrative system as well as the working unit. Indeed, the manpower situation found at MSFC also applies to MSC. In most non-governmental organizations, manpower tends to be controlled through the definition of financial parameters. This does not seem to be the case with the Apollo Program. One engineering manager consciously separated the two. "We could equate it primarily to lack of people to put on to solve a problem because they're busy working on other kinds of problems. The lack of money is not a problem." He added that the separation is not unique to Apollo. "The ability to give raises, to hire and to fire, that sort of freedom certainly affects all levels. It's a fundamental restriction to all government operations, so that's not unique to NASA. It's one of the most vexing restrictions."

One of the subsystems managers echoed these comments. "We also find that manpower is not directly related with funds. They just don't correlate." He went on to say, "As far as people go, I feel very definitely that I'm understaffed in this section, particularly with NASA people. I don't think this is a unique situation in this section. I think it's pretty well a center-wide problem with NASA personnel."

Again, this particular situation seems to be a unique circumstance of the organization rather than an additional control imposed by the

administrative system. Of course, from the point of view of the President and Congress and the Civil Service Commission, this is another control used to implement public policy.

Rewards

The model suggests that for working units in the engineered pattern performance evaluation of resource-utilization and output will rest with the administrative system while process evaluation will rest with the working unit, particularly the group leader. Also, the reenforcement of loyalty will be directed toward both the aggregate organization and the working unit. The interviews did not probe these questions and the propositions cannot be adequately tested. There were no comments which ran counter to these suggestions, and some seem to support them. In particular, the comments of one project manager on the dedication of the personnel seem to support the suggestions on the reenforcement of loyalty. "The program is run by dedicated people. And dedicated people I've noticed have an affinity for joining together mutually which even overrides personalities, although I think you have got to have the recognition of people for their intelligence. And you have to think really highly of other people asking these things, have confidence in them, and what they're doing is right."

Boundary Negotiations

The model suggests that for a working group in the engineered pattern, resources would tend to be a legitimate subject for negotiation, and that the administrative system would tend to emphasize resource parameters while the working unit would tend to emphasize output feasibility and

that once the program is crystallized, renegotiations would tend to be legitimized by the working unit on the basis of process requirements. Though the interviews did not probe the question in these terms, the comments above on the determination of financial parameters would seem to substantiate resources as a subject of negotiation. In addition, the comments of one engineering manager on the resolution of problems supports these suggestions. "We go to our resources division here and ask for the funds and they see if there are enough funds within the Center resources that they can reallocate money to our need, and if not, we'll have to go back and ask Headquarters for additional resources for this."

Also, the attitude represented by the following comments of one of the vehicle managers seemed to be fairly representative and support the model's suggestions. "It was a determination that we had some very serious deficiencies in the design. They had to be fixed if the program was to succeed and the cost of fixing them was relatively minor compared to the total cost of the program."

Finally, the comments of one of the project managers indicate that process requirements, in terms of engineering changes, justified exceeding the established financial parameters.

> "Last year we didn't have good dollar control on the project because we were making a lot of changes. We went way out of our budget and we had very little pressure on us in terms of cutting funds back. You get the occasional back of the hand, but not really constant day to day pressure. Now this year, it's been tougher because we were short and we've had to try to live within a total dollar ceiling, so I spend a lot more time on cost this year, than I did last year. Now I've forecast that I'll probably spend a little more next year because we're beginning to move towards program close-out and our program may not be closing out as fast as our funds are closing out."

## The Administrative Relationships of the MSC Project Management Groups

Of the four characteristics of the relationships between the administrative system and the MSC project management groups specified by the model, the interview data substantiate one, support two, and do not test the fourth. The interviews did not probe the division of the planning responsibilities for MSC, but the comments on the control relationship follow the outlines suggested by the model. The propositions on boundary negotiations and, to a lesser extent, on rewards are supported, though not fully tested by the results of the interviews.

## The Perceptions of Administrative Personnel

Further support for the propositions on the relations with the administrative system can be derived from the interviews with members of the administrative system. These were mostly personnel of the Apollo Program Office at NASA Headquarters in Washington, D.C., and their comments deal particularly with the planning and control relationships. These comments were not discussed in the earlier sections because in most cases there was no effort to distinguish between MSFC and MSC.

### Planning

One division chief emphatically supported the proposition that the ends, or basic requirements, of the Program are set by the administrative system at Headquarters.

> "The requirements - program requirements - are established here at headquarters. They're generated here at headquarters. That doesn't say that this is an ivory tower. They're generated through a lot of meetings and a lot of discussions with the Centers and they eventually reach our Management Council where the decisions are made. Of course this goes way back in the program and has been continued. These then are set forth as NASA Headquarters requirements and

> they're documented, and in the case of the Apollo Program, the specific method we have is the Apollo Program Directive . . . ."

Further support for this position comes from the comments of one member of the Apollo Program Control Office. "Every six months, previously every quarter, we conduct an overall budget review. The process basically is developing and setting out guidelines which define the program content, schedule, etc. that they are to work on and budget for."

In describing the process further, he illustrated another proposition on planning, that the resources are established through joint negotiation.

> "The POP, Program Operating Plan, team visited each center and reviewed their requirements. They presented the guidelines that they have interpreted from our broader guidelines; in other words, their one level lower detail guidelines. They say to us, your guidelines were such and such, and we have interpreted that into this and this and this. Here's the basis on which we submitted our budget, which, by the way, turns out to be another place where you sometimes find that the Center interpretation isn't quite what you meant up here. We meant the guidelines would be thus and thus, therefore it looks like we can save $10 million. They said sure, no problem. So there's that kind of thing. We listen to their presentation and then consider all of these factors . . . ."
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Another member of the same office also supported this position in discussing the resolution of budgeting problems.

> "It's each person's preference on how you want to handle the field centers. My own preference is that we go back to the field centers and say, here's how we think you can solve your problem, but you can actually solve it any way you choose. If you feel another way is more appropriate, go ahead, solve it the way you want. That's normally the way we do it. We give them the rationale for what we think, but we certainly enable them to quarrel with us."

Finally, one of the NASA budget division personnel makes the same point even more emphatically.

> "The headquarters staff is very careful not to dictate to the Center Director exactly where they should take reductions because he has been delegated the job of getting a scope of work done and

> his allocations of resources is the way in which it gets done. The headquarters staff can make recommendations, and he doesn't have to accept them except as to certain control totals. And if he doesn't like those control totals he comes back to the Program Director and makes his unhappiness known and they work it out. But there is a quite considerable flexibility in the allocations to the Centers, on purpose. The Centers are responsible for getting the job done."

Control

One of the Program Control personnel commented broadly on the controls used in the Apollo Program.

> "I guess the things that we do control from Washington are so-called control milestones of which there are about 300 of them. There are the budget line items at the project level. In other words through the POP - Program Operating Plan - process semi-annually and configuration changes through level one CCB [Configuration Control Board] and through those three general means of control the Apollo Program Director has a positive directive authority over the field center."

This would support the suggestion that critical control points are used and that financial parameters are defined at least partly by the administrative system.

Another headquarters person who worked on the Apollo budget pointed out, "The entire resource system of the agency evolves from attempts to have a grass roots budgeting, attempts to get all its data up from the centers to headquarters . . . ."

This does not negate the suggestion of joint negotiation, as one of the Program Control people pointed out.

> "We don't just take the center input. NASA is traditionally heavily biased towards a strong field center organization; because of this tremendous talent there is a good reason for it. But we have to really look at everything we get from the Centers, because it's an awfully complicated business and nobody has been right 100% of the time. So, we're another check and we do this."

One of the other Apollo Program people mentioned that this relationship developed over the course of the program.

> "In other words, dollars, initially were you asked for and you got them, and now we're not in that position. So I think the economics of the situation have put the reins of control, and let's face it, money is a marvelous controlling item, into the hands of the people that need it. So in this case you could say our slimmed down budget's probably done us some good, helped us out in this area. We didn't have that initially. That goes back to the autonomous operation, when the Centers came in asked for so much money, and if I may put it crudely, they were rubber-stamped and on their way."

The following comments of one of the Apollo Program Office personnel indicate that the process decisions were not made at Headquarters.

> "We don't have up here, of course, a large engineering staff which does a lot of detailed engineering. It's a broad management monitoring kind of staff which really in a nutshell, its sole purpose is to keep the Apollo Program Director informed of these kinds of problems that are either potential or real, or if the problem is being worked, to keep them alert, to keep them abreast of the status of it and if it gets out of hand, recommend what to do to get it back in hand."

This is corroborated by the comments of another Apollo Program Office person on the decision on trade-offs between technical requirements, schedule requirements and cost limitations. "Normally, we don't make the trade-offs as much as forcing the Center to make them so that when they bring their recommendation forward they plot out what they're doing."

He went on to distinguish his responsibility rather clearly from that of the project management group.

> "My responsibility is overseeing the project and making sure that its activities are consistent with the program. We do not do the detailed engineering nor are we responsible for the implementation of this with the contractors. We are, however, responsible to the program director for the carrying out of the implementation pursuant with the requirements of the program."

## Summary

In this section, the propositions of the model on the relationships between working units and the administrative system were applied to the project management groups at MSFC and MSC. In addition, the views of personnel in the administrative system were examined to shed further light on the question. The interview data furnished considerable support for the propositions, particularly those concerned with the division of planning responsibilities and the control relationships. Though the propositions on rewards and boundary negotiations were not adequately tested, there were indications that these also fit the experience of the project management groups.